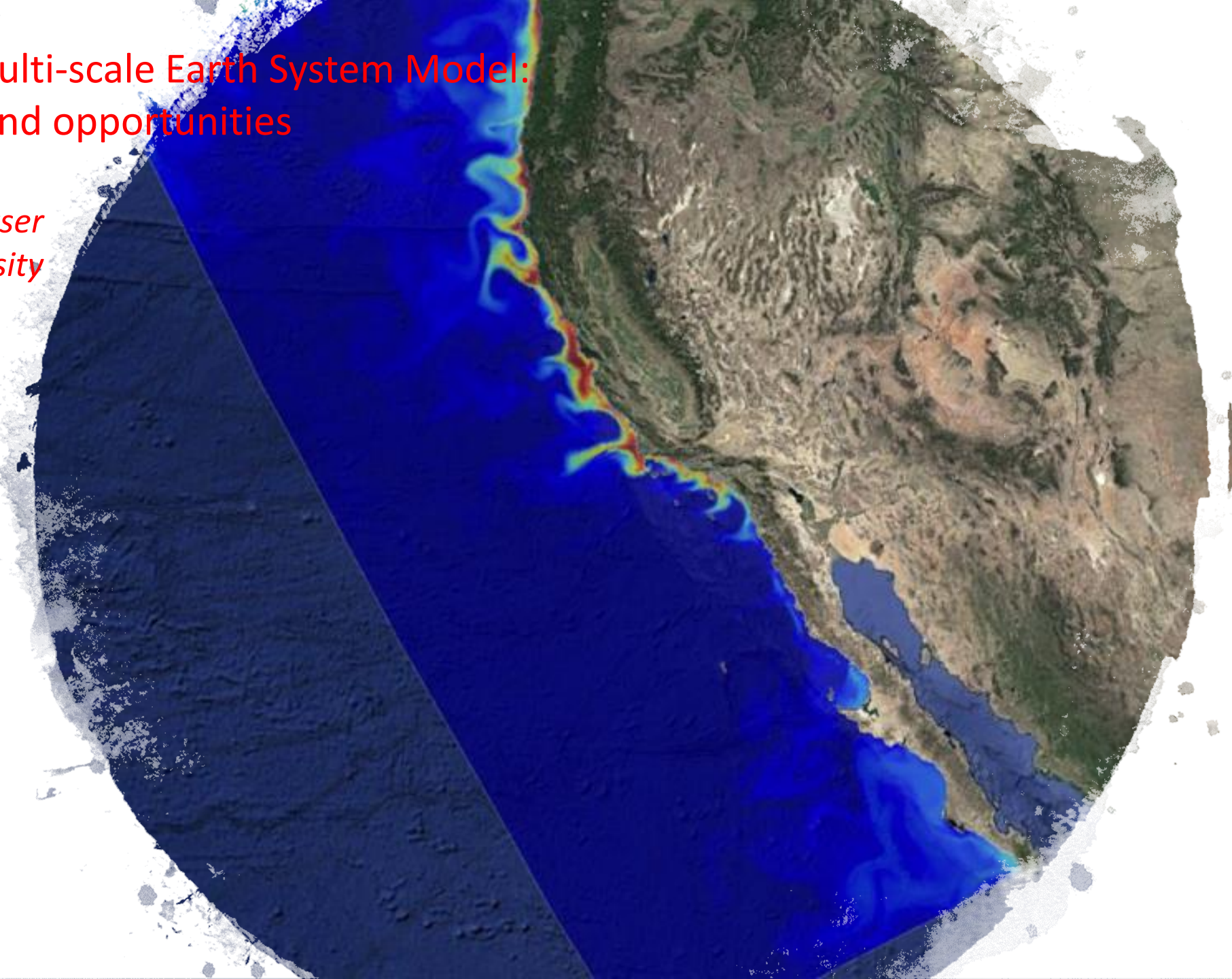
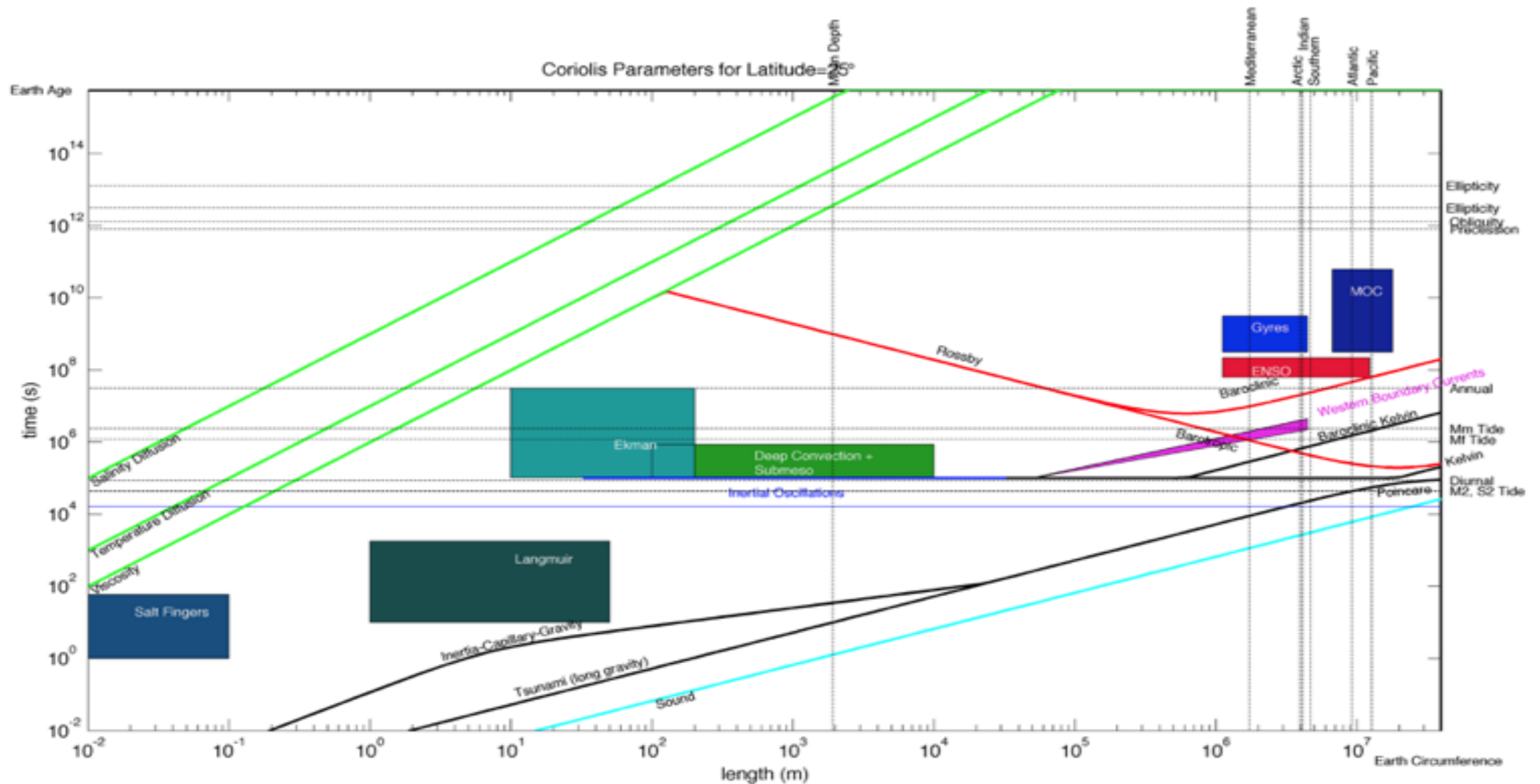


Towards a multi-scale Earth System Model: Challenges and opportunities

Enrique Curchitser
Rutgers University

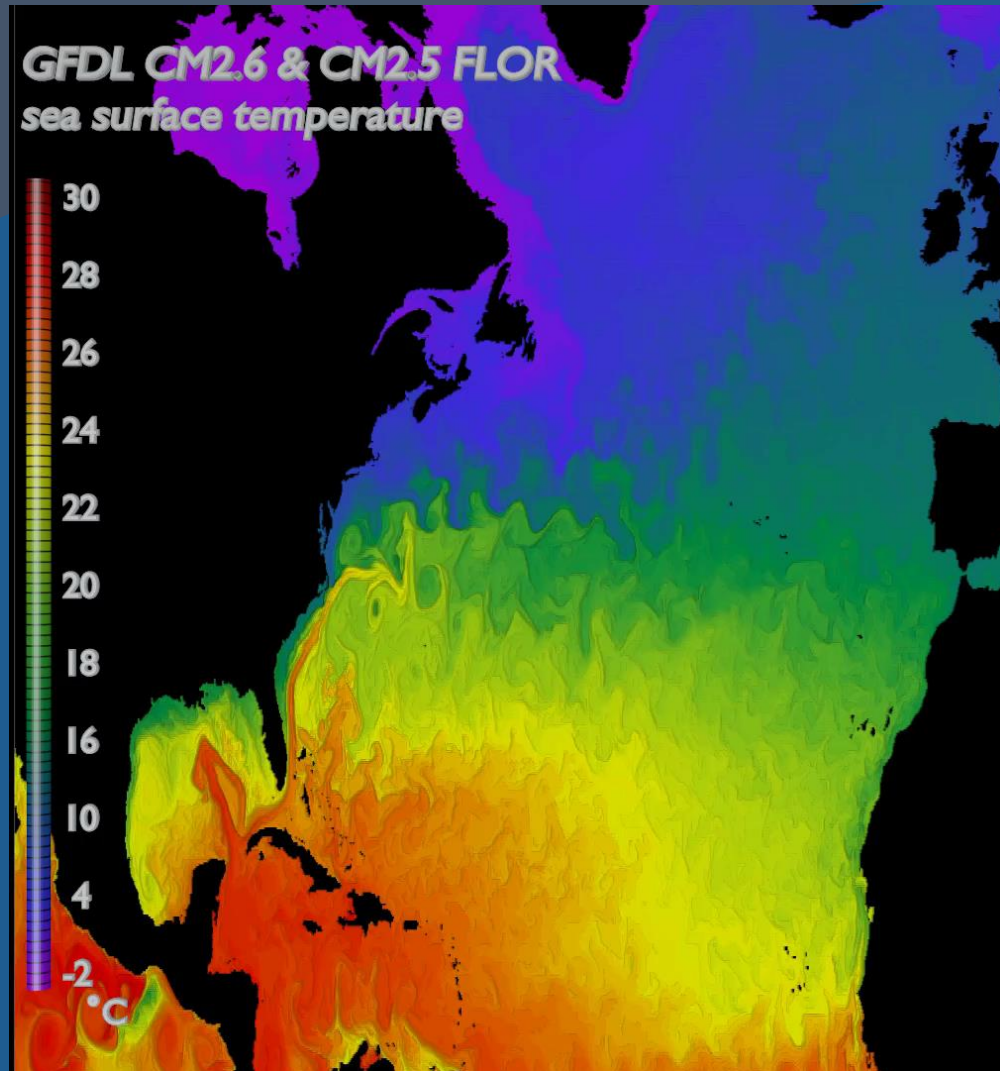




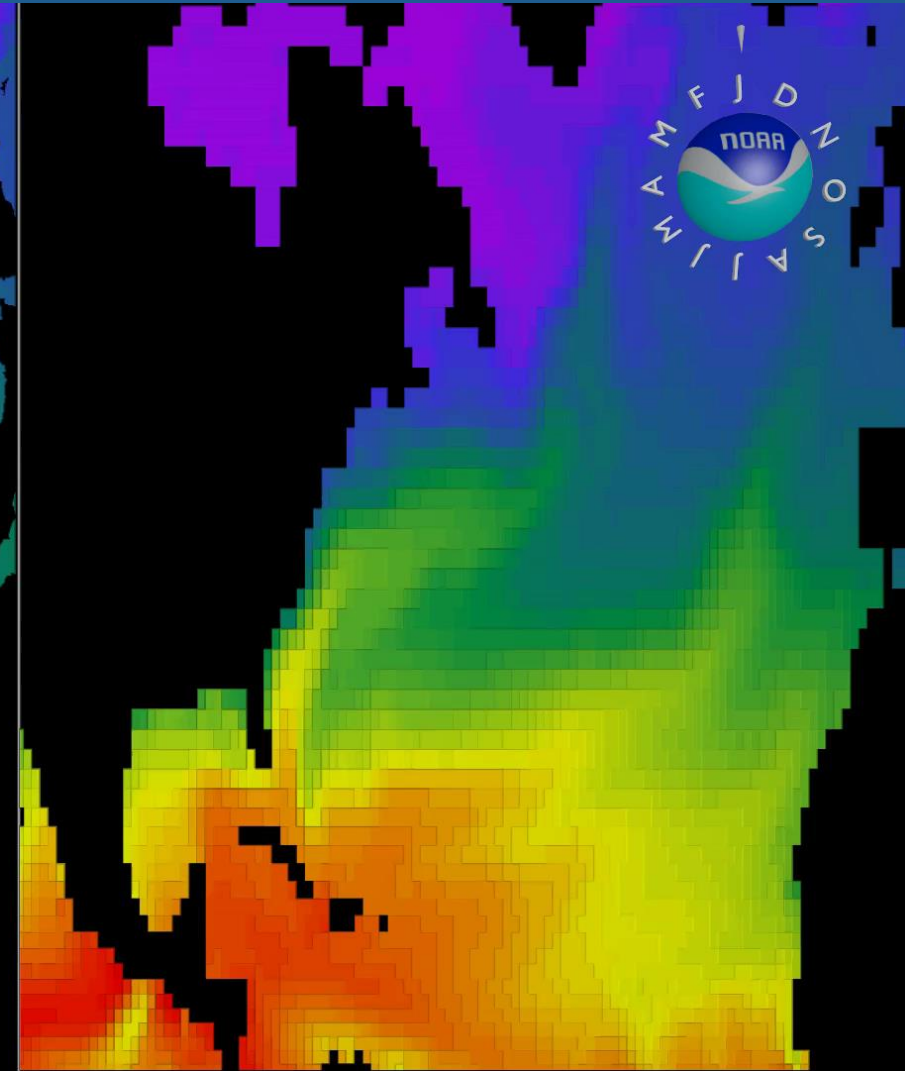
Space-time scales of some oceanic processes

Haidvogel, Curchitser, Danilov and Fox-Kemper (2018). Numerical Modelling in a Multi-Scale Ocean. *The Sea*

Global Climate Models: Resolution



High-Resolution Ocean (10 km)

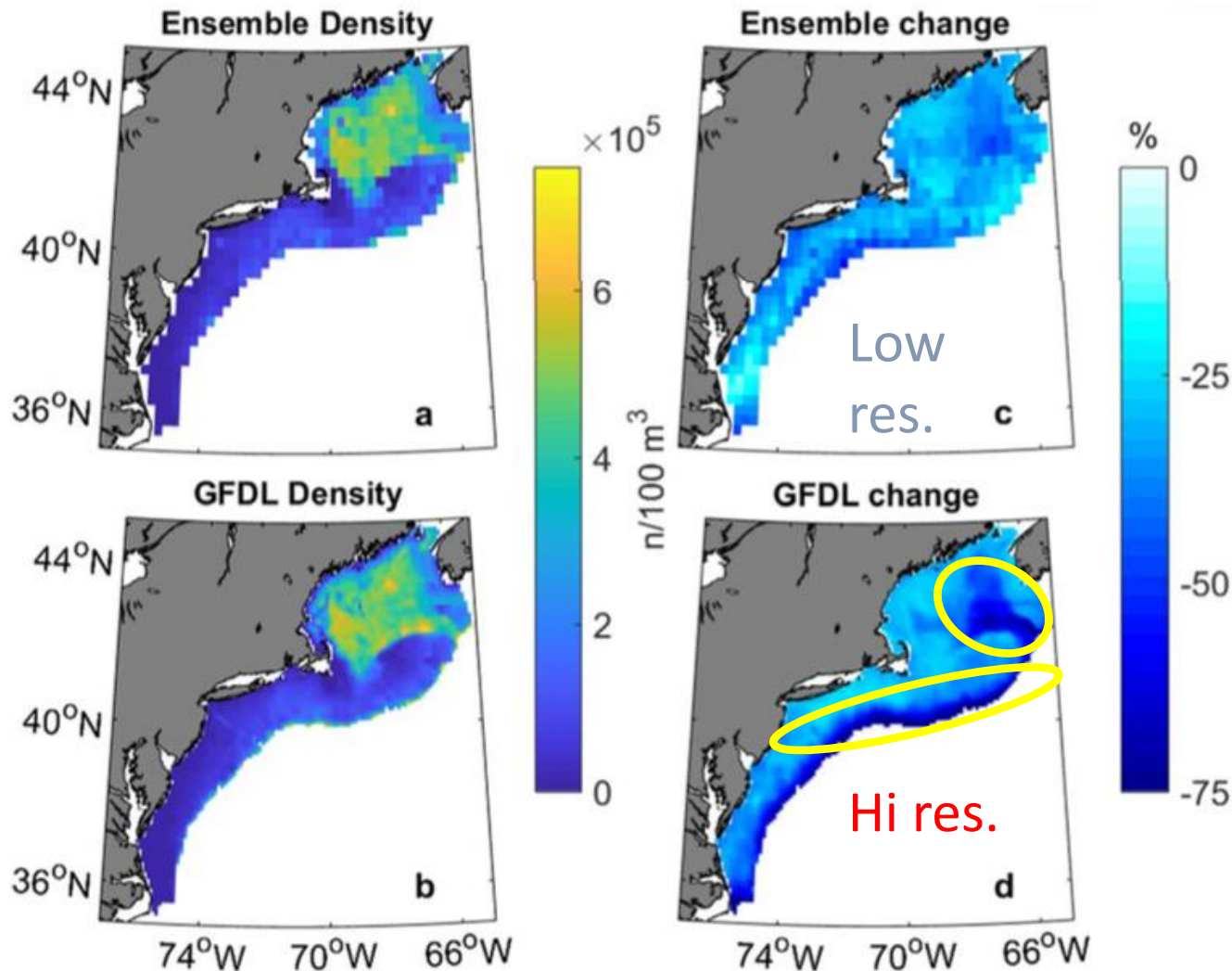


Low-Resolution Ocean (100 km)

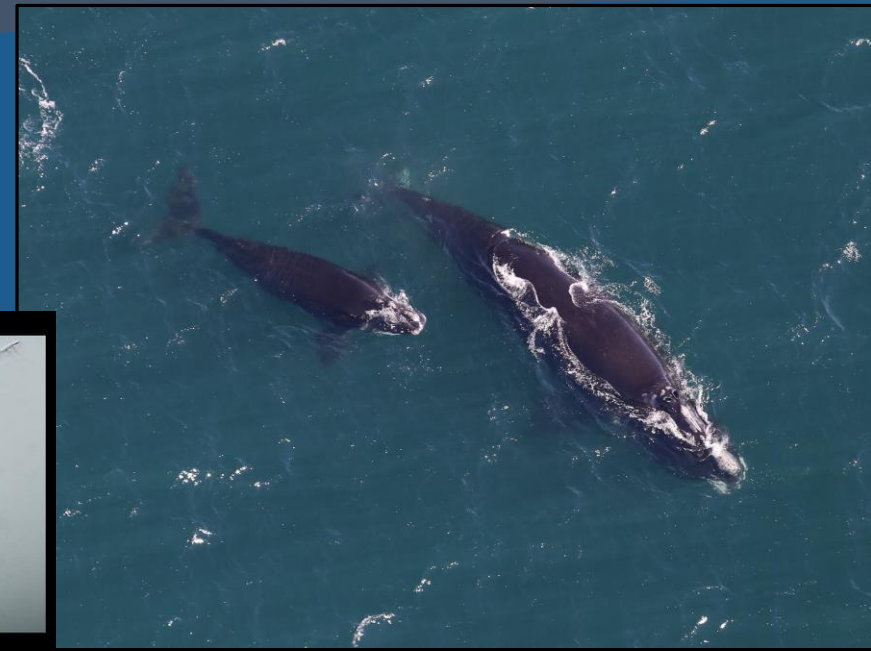
(Slide courtesy V. Saba)

Calanus finmarchicus projection based on NOAA GFDL's high-res. climate model

Calanus finmarchicus habitat climate change projection based on NOAA GFDL's high-res. CM2.6.



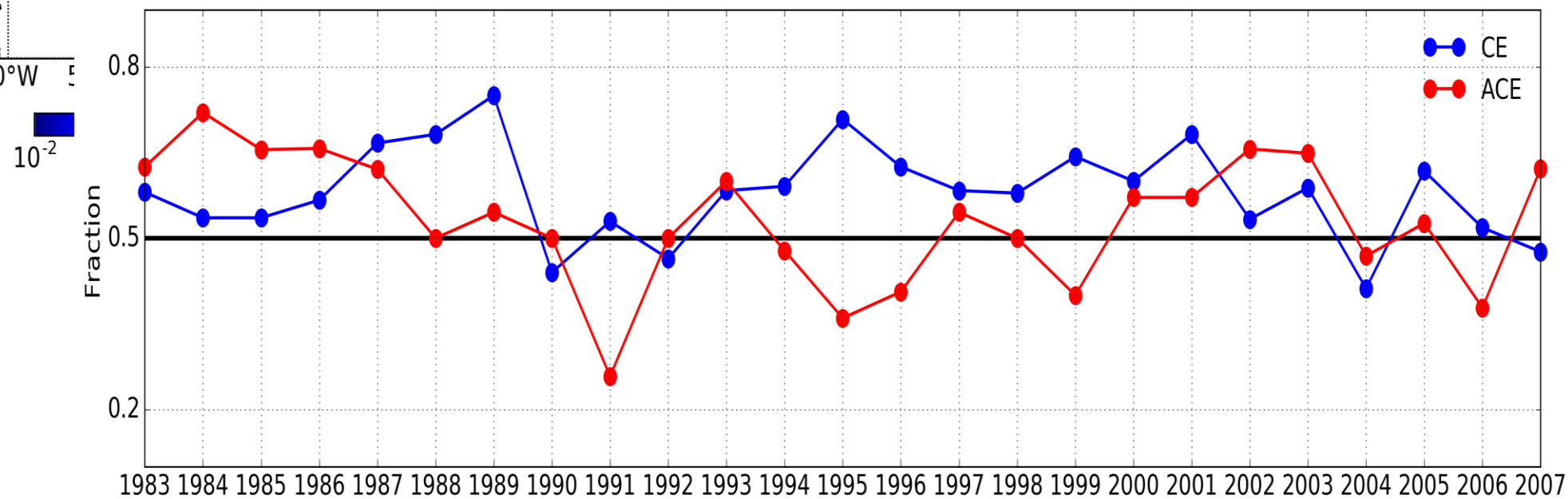
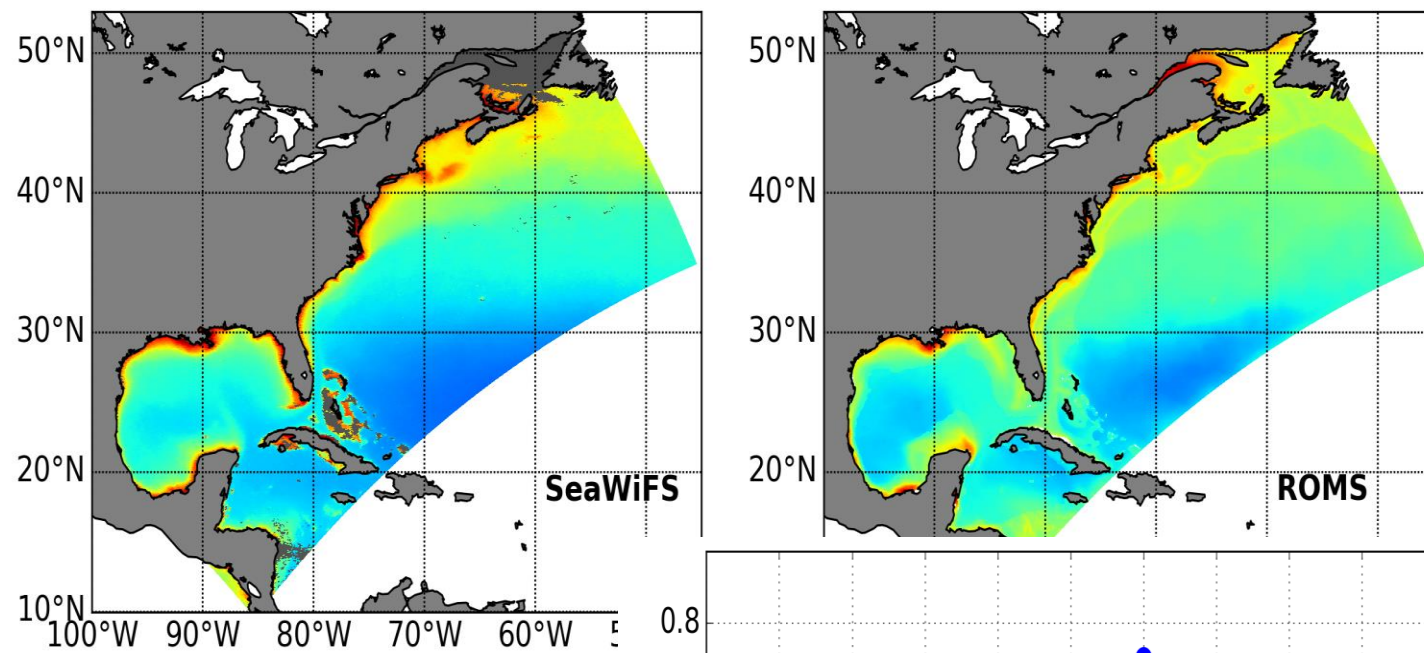
Calanus finmarchicus



- By 2081–2100, average *C. finmarchicus* density projected to decrease by ~50% under a high GHG emissions scenario.
- The high-resolution model showed larger decreases in the **Northeast Channel, Central Gulf of Maine, and Shelf Break.**

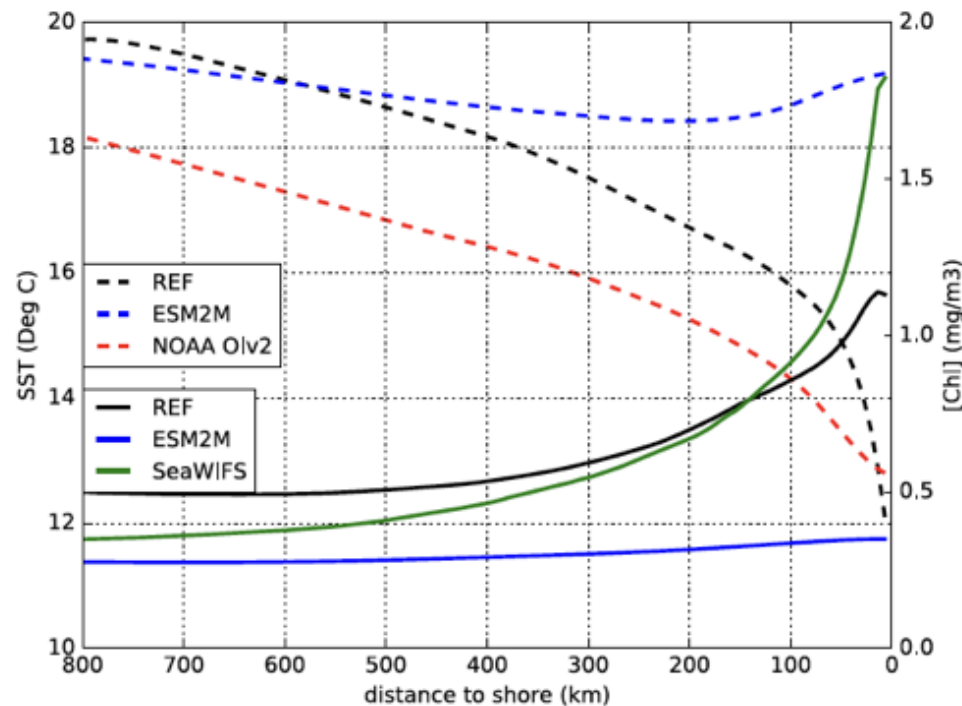
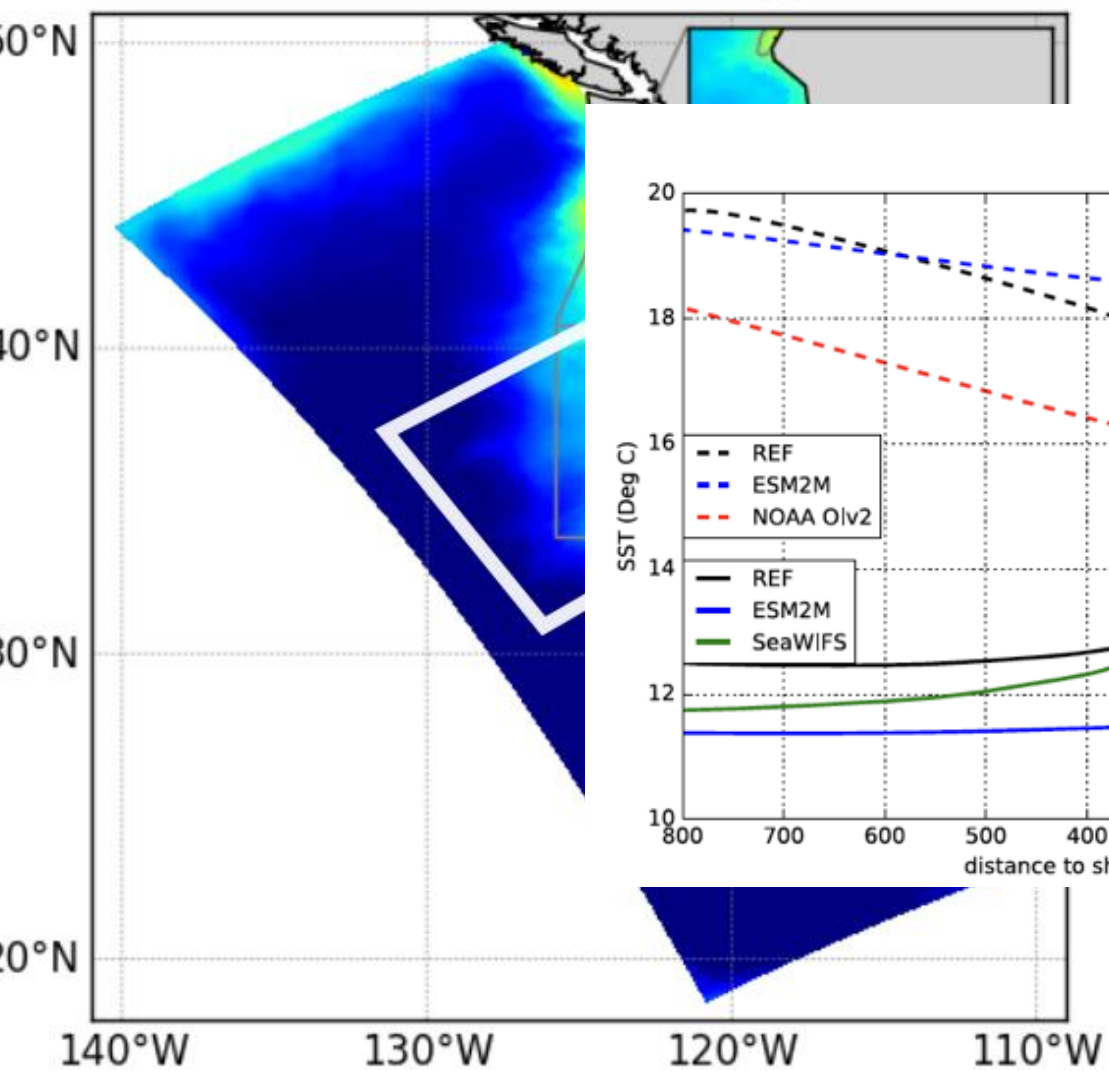
(Slide courtesy V. Saba)

U.S. Department of Commerce |
National Oceanic and Atmospheric
Administration | NOAA Fisheries |

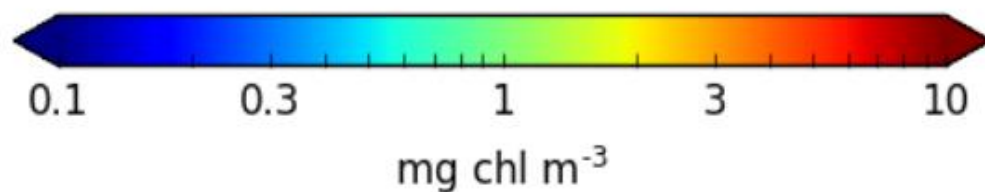
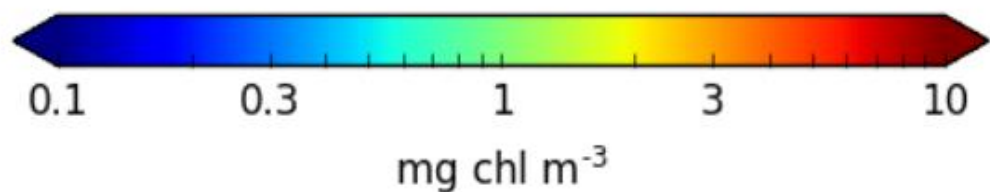
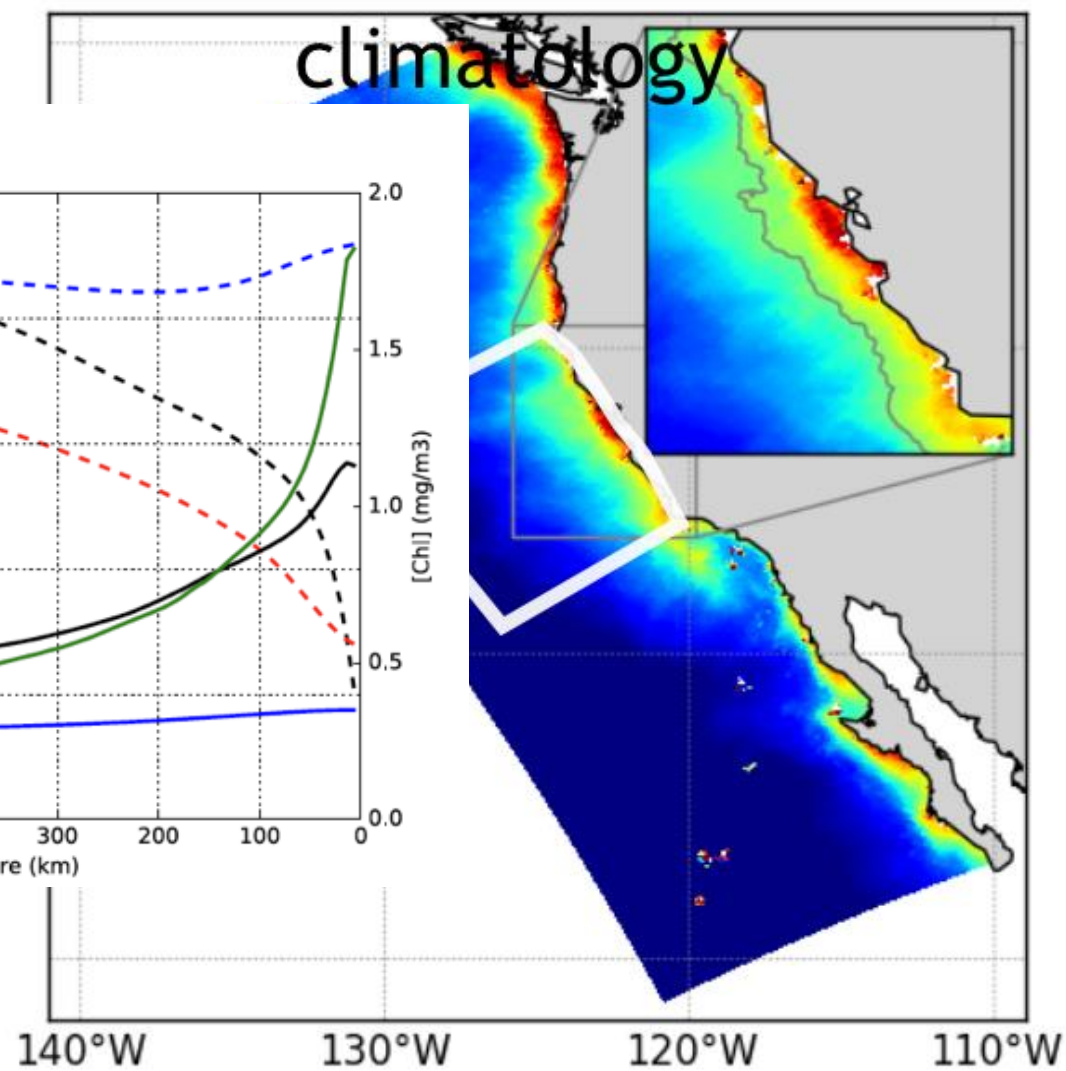


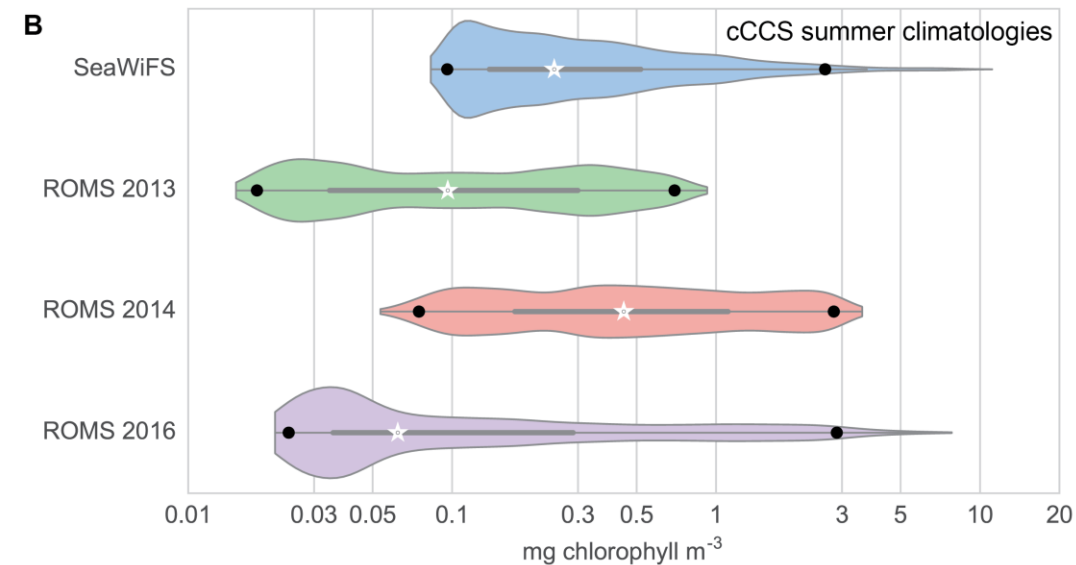
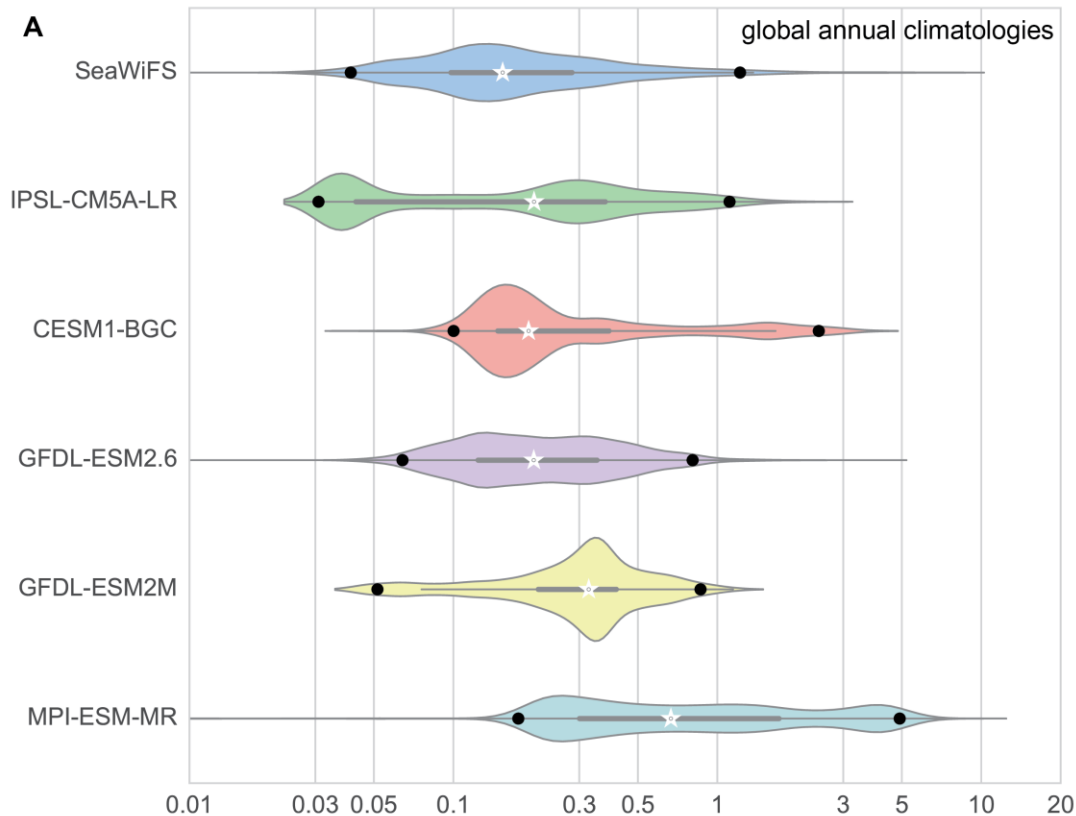
Zhang, Curchitser, Stock, Kang & Dussin (2018). *Impact of mesoscale eddies on vertical nitrate flux in the Gulf Stream region*

JJA climatology

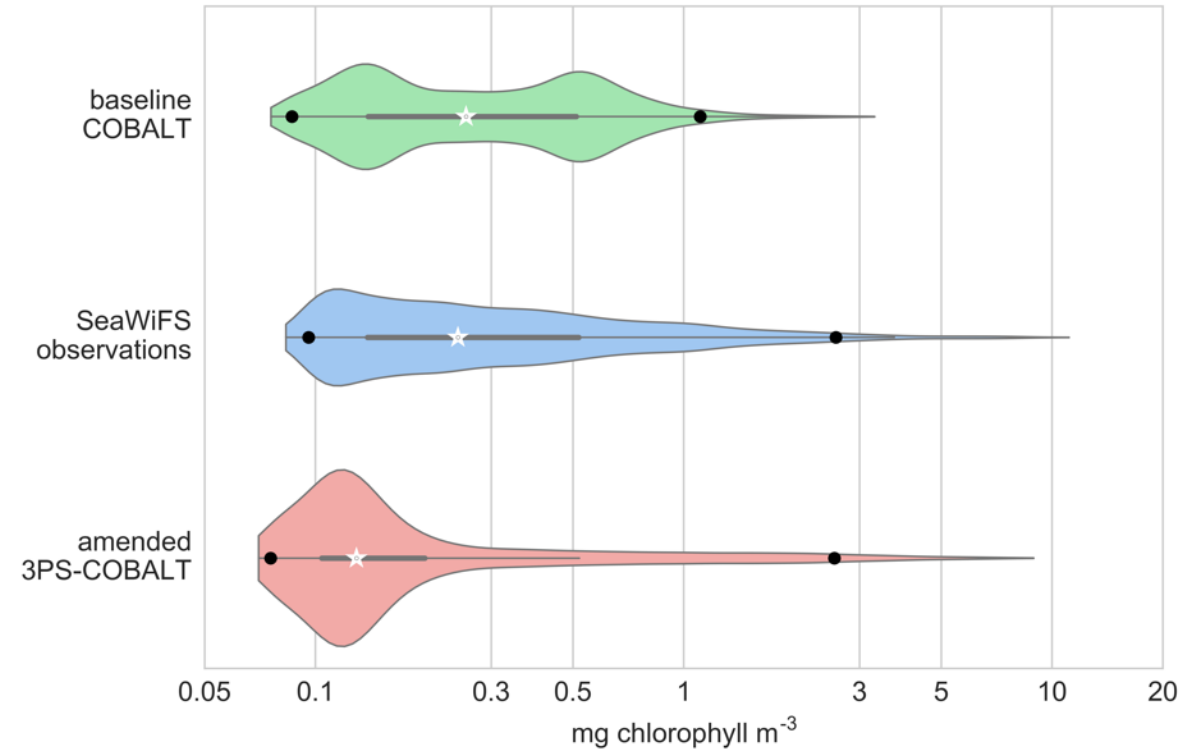


SeaWiFS JJA climatology



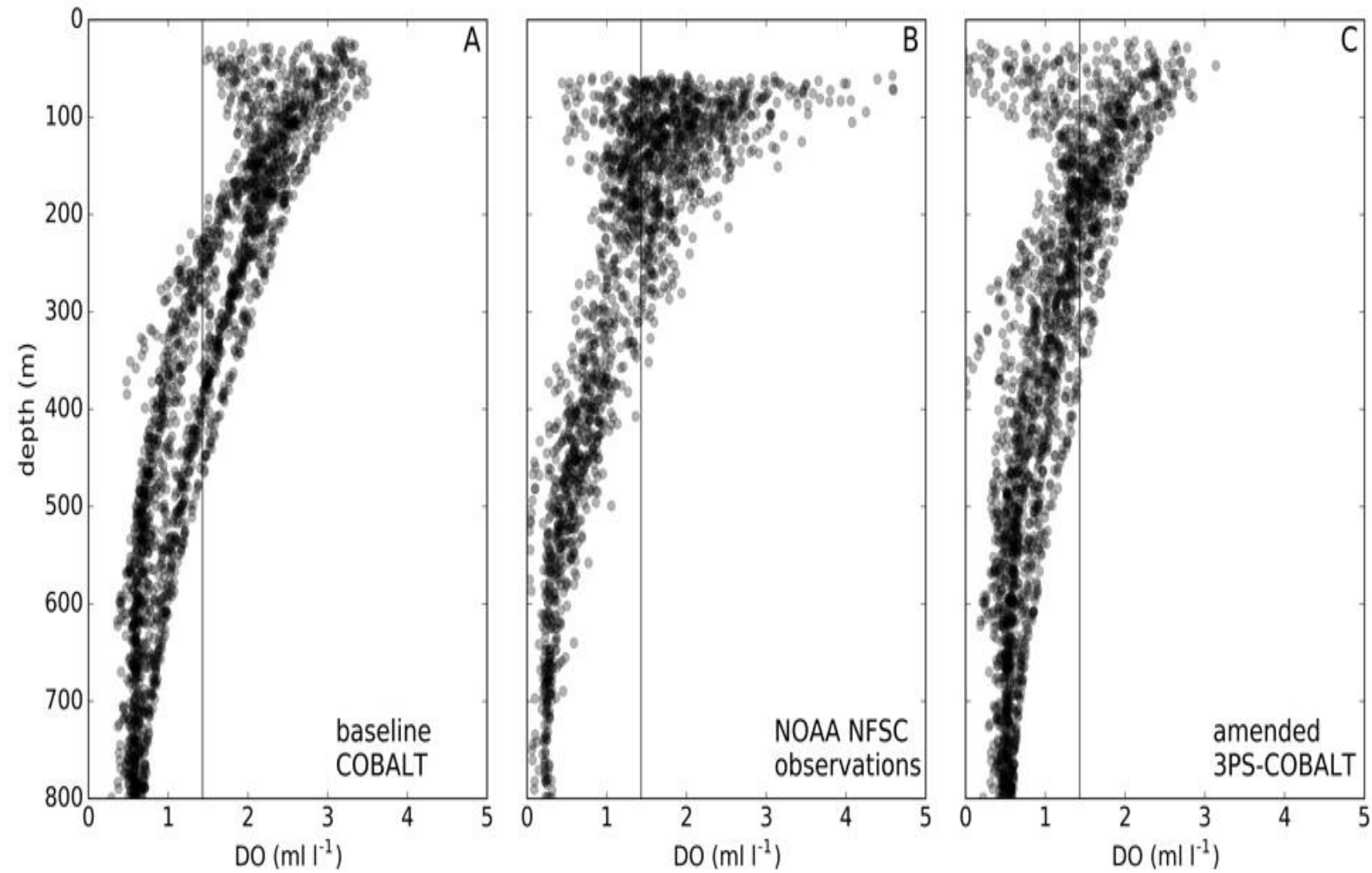


CCS: PDFs of Chlorophyll classes



Van Oostende, Dussin, Stock, Barton, Curchitser, Dunne & Ward (2018).
Simulating the ocean's chlorophyll dynamic range from coastal upwelling to oligotrophy.

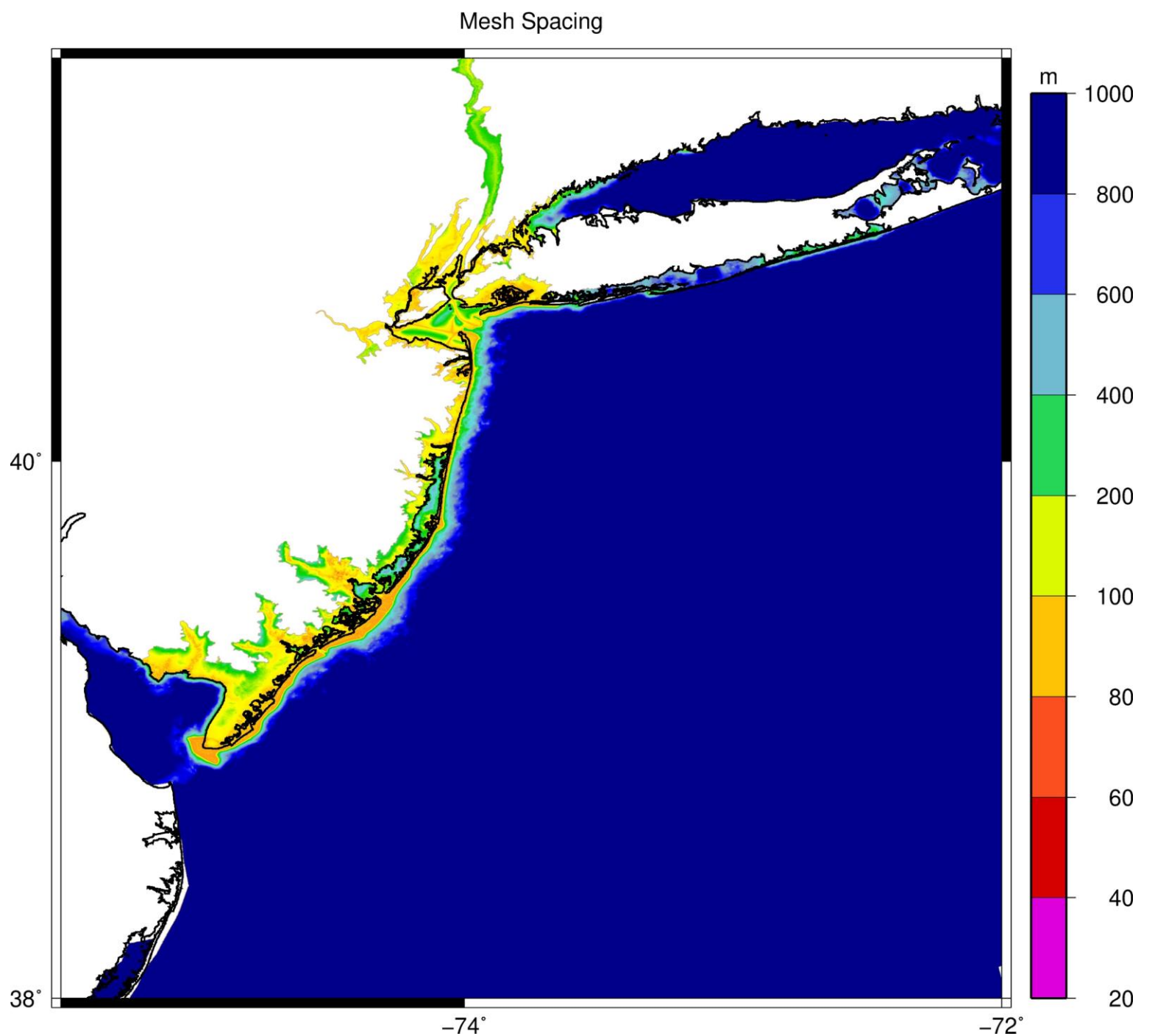
CCS Bottom Oxygen



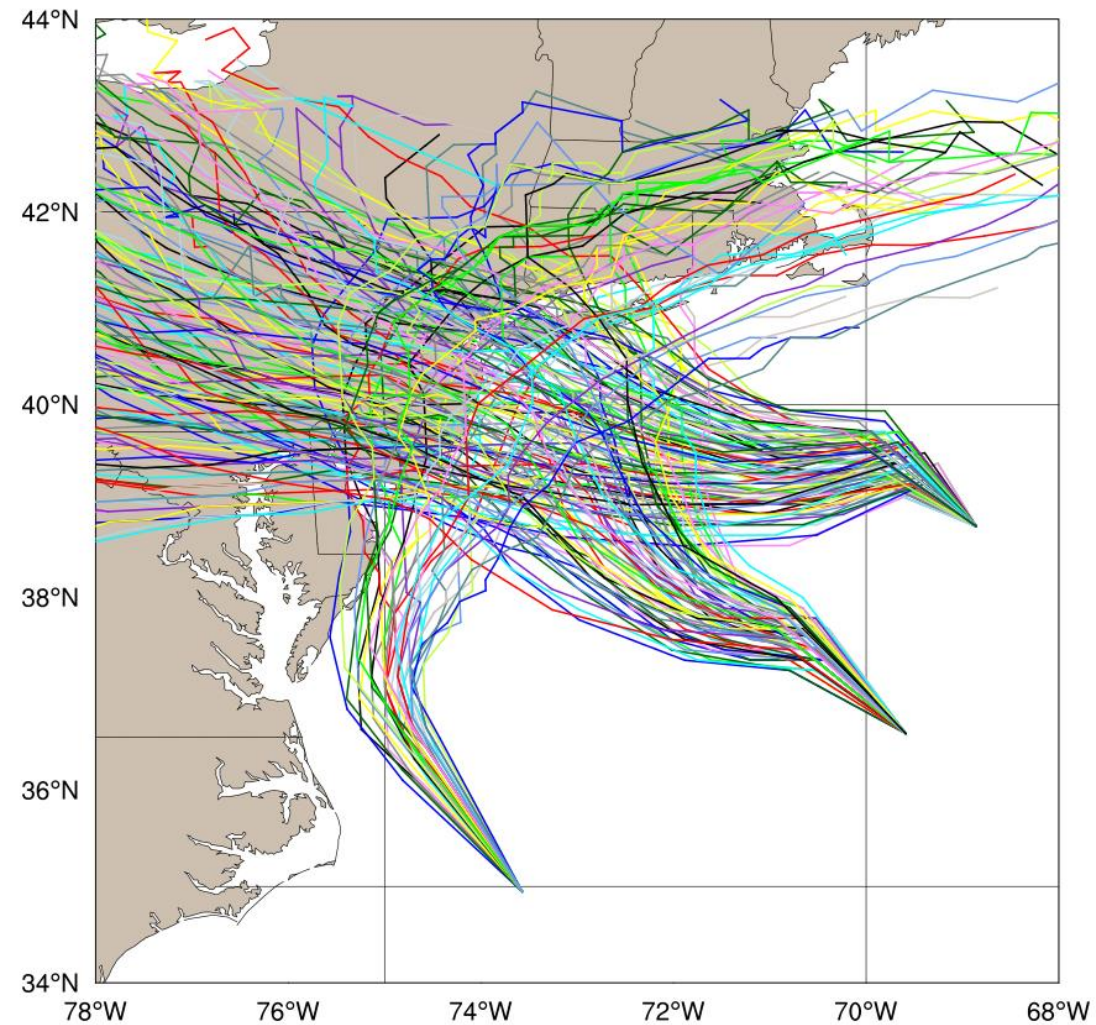
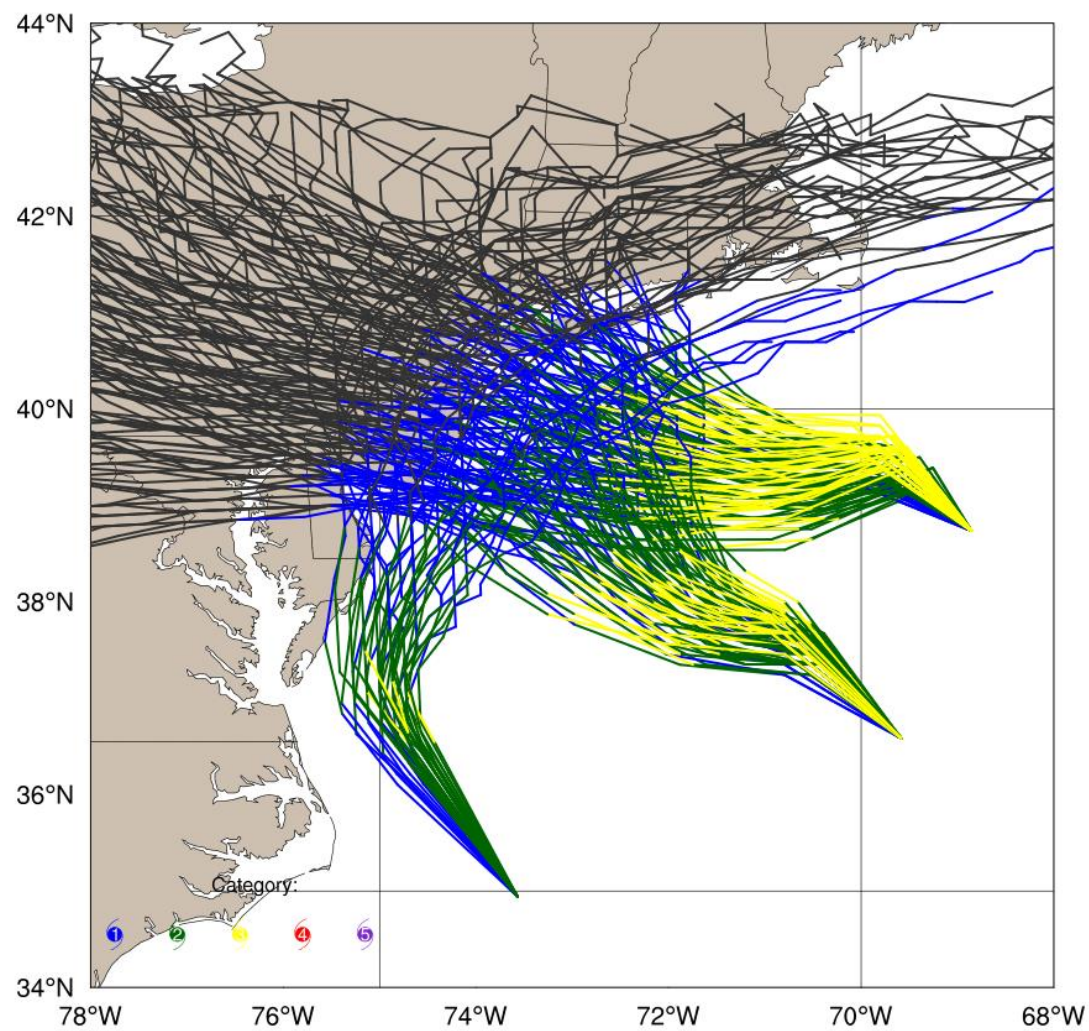
Van Oostende, Dussin, Stock, Barton, Curchitser, Dunne & Ward (2018). *Simulating the ocean's chlorophyll dynamic range from coastal upwelling to oligotrophy.*

Coastal climate impacts: May need really high resolution (< 100m). Needed to resolve barrier island, inlets, harbors, etc.

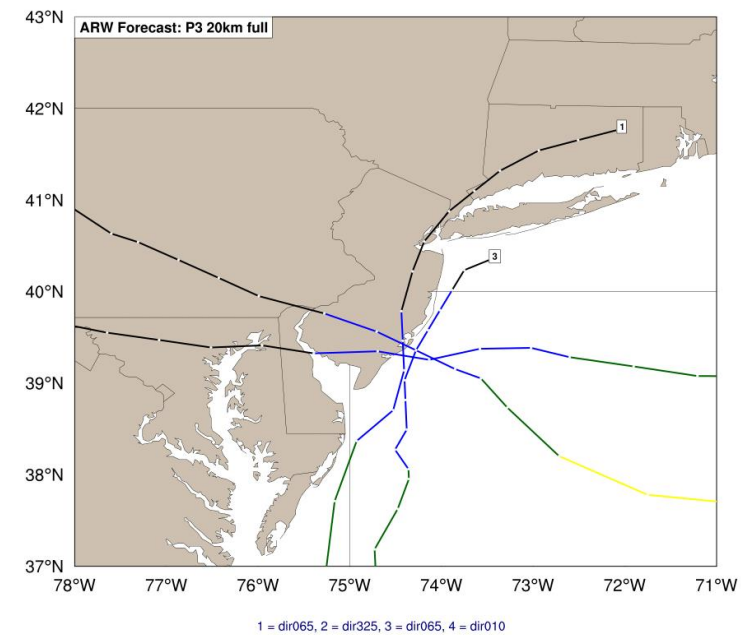
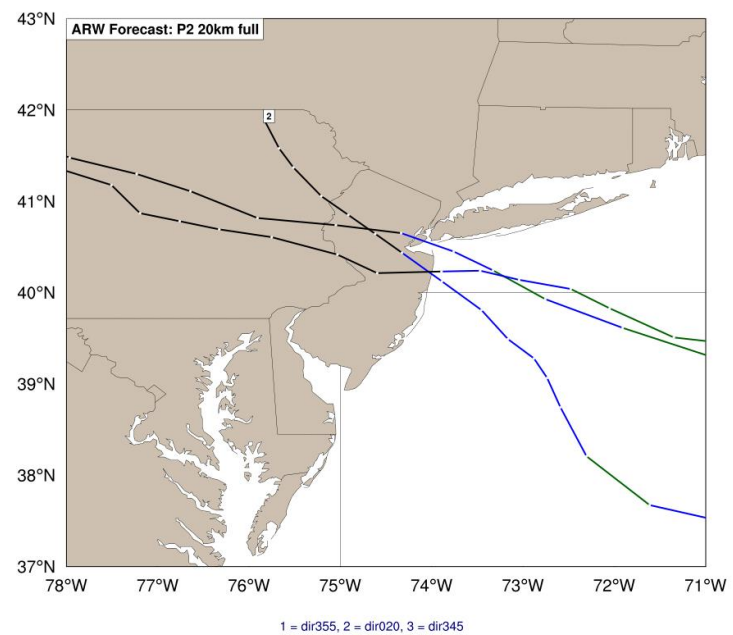
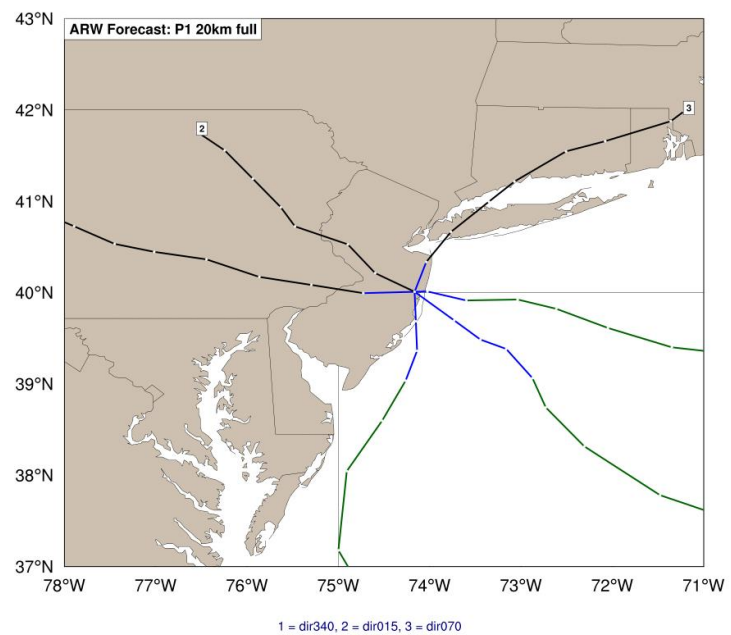
Also for offshore wind energy-- prediction is an important component.

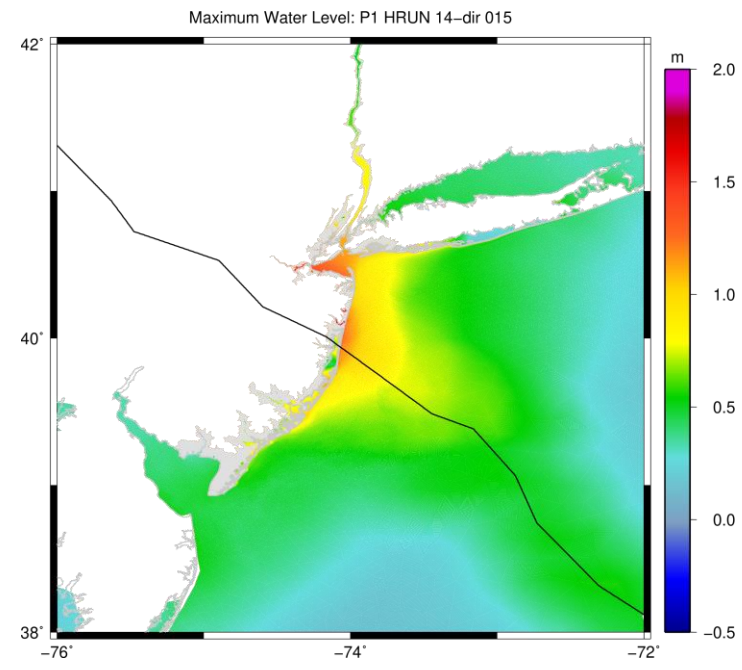
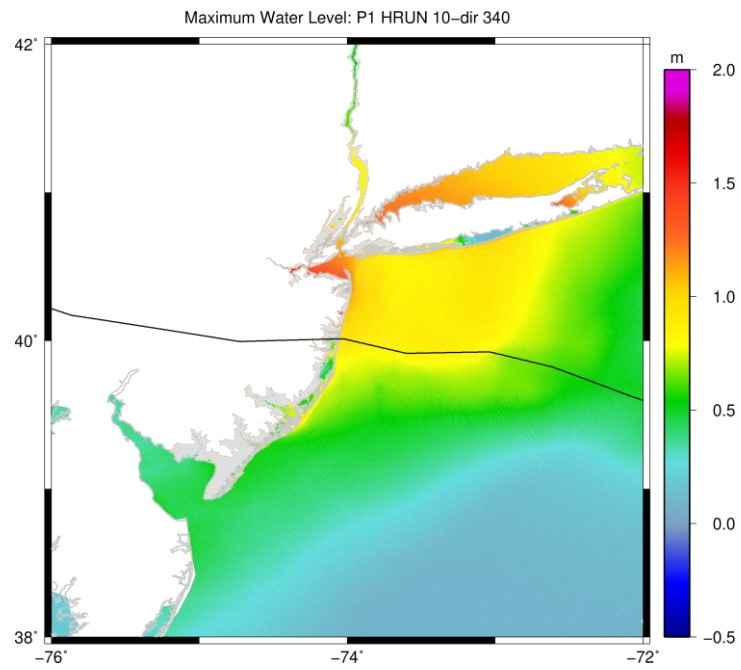
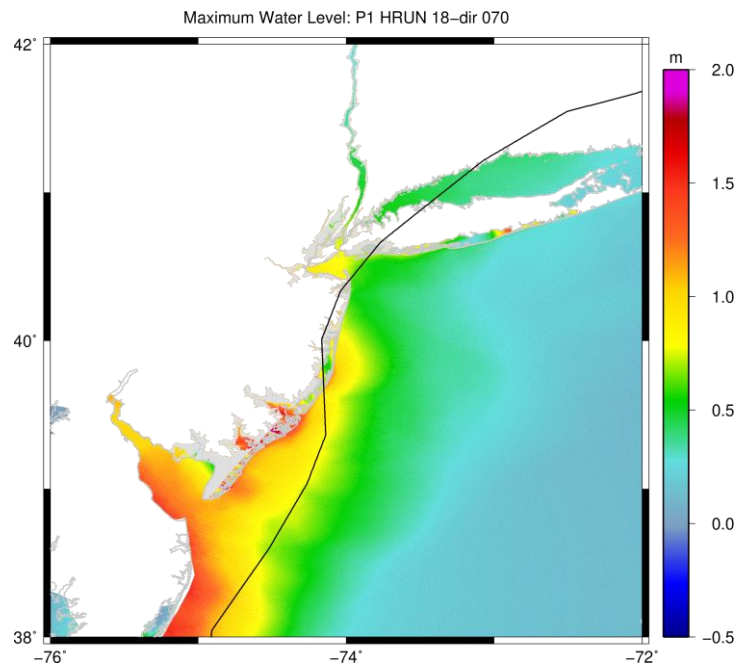


Impacts: Synthetic storms and inundation



N=198 + 8 (No LF)





Looking forward

Challenges

- Computational cost, especially for ensembles
- Parameterizations
- Data, data, data
- Regional boundary conditions—physics, biogeochemistry

Opportunities

- Regional Earth System models
 - Look beyond BGC—upper trophic levels, energy, economics...
- Variety of downscaling approaches—statistical and dynamical techniques
- Consistent “discretization” across scales